WATERSHED BIOASSESSMENT REPORT

WHITE LICK CREEK WATERSHED
MORGAN COUNTY, INDIANA

April and October 2004

Study Conducted By:

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EXECUTIVE SUMMARY

A rapid bioassessment of the benthic macroinvertebrate community of the White Lick Creek watershed in Morgan County Indiana was conducted April and October 2004. The purpose of the assessment was to document the biological condition of the streams. Twelve sites were examined in the Mooresville and Brooklyn areas.

The study showed that White Lick Creek and the East Fork of White Lick Creek had excellent aquatic habitat. In addition, two tributaries (Monical Branch and Orchard Creek) had relatively good water quality. However, based on deviations between available habitat and the “index of biotic integrity” scores, water quality was degraded at the White Lick Creek and East Fork of White Lick Creek sites. Biological indicators point to the presence of low-level amounts of toxic substances and excessive nutrient inputs in White Lick Creek. In addition, the biological communities were indicative of excessive sedimentation. The degree of degradation was relatively constant as White Lick Creek entered and flowed through Morgan County. The water quality impairment may include sources both upstream and within in the study area.

Recommendations to improve conditions in the watershed include:

(1) Protect habitat by discouraging channelization and clear-cutting of riparian vegetation.

(2) Reduce sedimentation by controlling bank erosion, and encouraging good land-use practices.

(3) Coordinate with agencies upstream to improve water quality.

INTRODUCTION

A 319 nonpoint source grant was awarded to the Morgan County Soil and Water Conservation District to identify water quality problems in the White Lick Creek watershed in the Mooresville and Brooklyn areas. An important component of the grant was to conduct a series of bioassessments in these streams. Bioassessments are recognized as a valuable tool in identifying water quality problems and helping diagnose their causes [1]. Certain animals are sensitive to different types of stresses. Comparison of the numbers and kinds of animals present can give important clues about the presence of toxic substances, excessive sedimentation, excessive nutrient inputs, or low dissolved oxygen concentrations.

This project was designed to characterize the biological and physical (aquatic habitat) integrity of the streams in the White Lick Creek watershed in Morgan County. Questions to be answered include:

What is the overall ecological health of these streams?

Are unhealthy streams affected primarily by degraded water quality or degraded habitat?

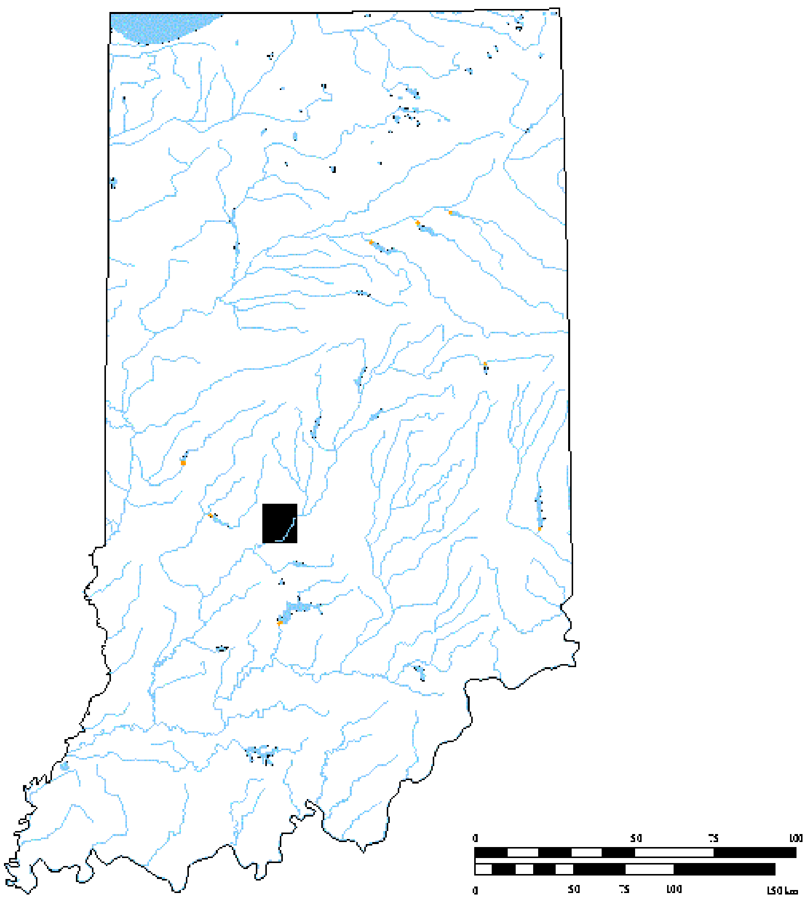
Are dissolved oxygen, pH, temperature, and conductivity within normal ranges for aquatic life?

What can be done to make the identified problems better?

Local Setting

The streams in this watershed (Fig. 1) lie in the "Eastern Corn Belt Plain" ecoregion of the Central U.S. This area is composed of a glacial till plain manteled in many places with loess. Stream valleys are generally shallow with narrow valley floors. Constructed ditches and channelized streams are common because much of the ecoregion has poorly drained soils. The natural vegetation consists of a mosaic of bluestem prairie and oak/hickory forest. However, a great majority of the land in this ecoregion is used for agriculture, primarily for corn and soybeans [2].

Figure 1.

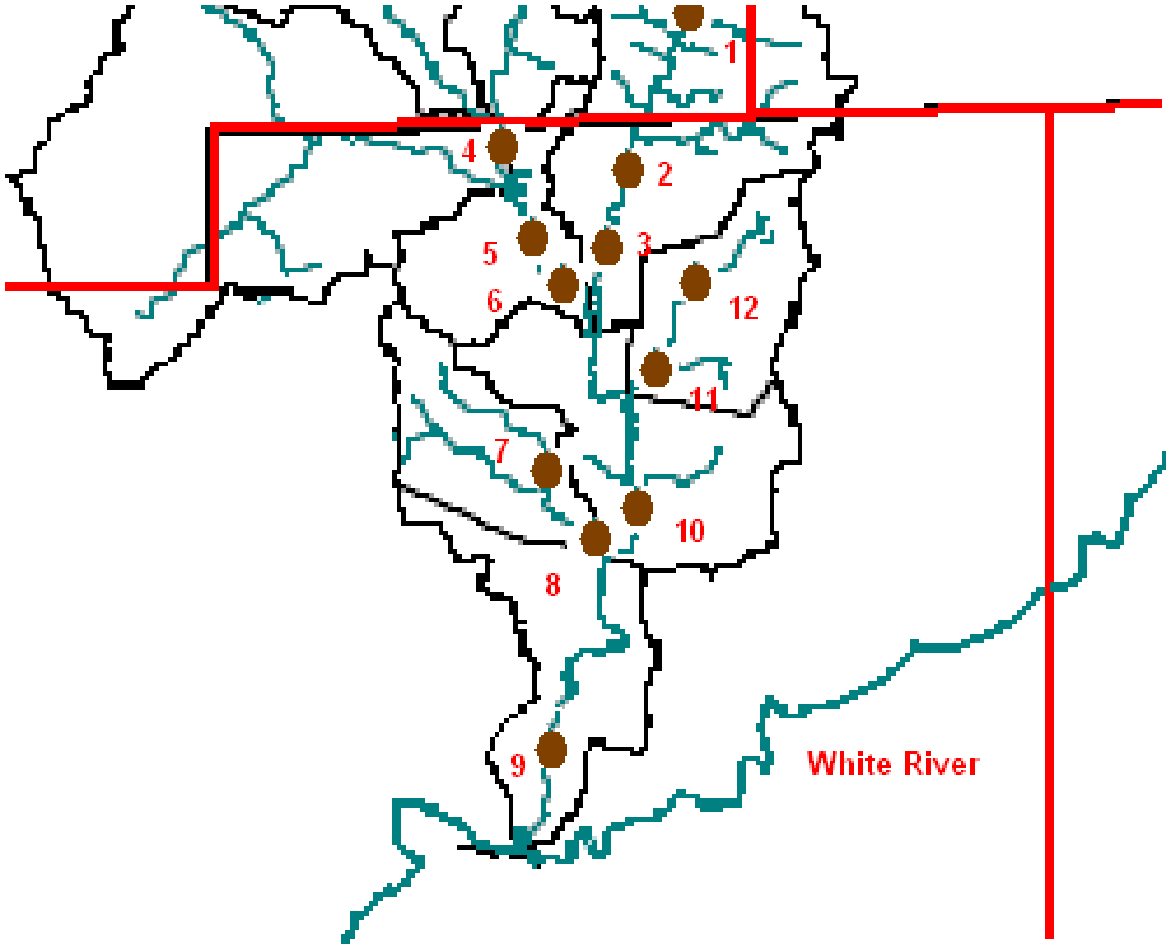


The Present Study

To document the biological integrity of the watershed, twelve sites were chosen for study (Fig. 2). Site locations were as follows:

	Stream	Latitude	Longitude
Site 1	East Fork White Lick Cr. CR 700S Hendricks Co.	39.39.38.2	86.20.26.6
Site 2	East Fork White Lick Cr. Old SR 67	39.37.27.2	86.21.26.8
Site 3	East Fork White Lick Cr. E. Carol Ln.	39.35.40.9	86.22.0.7
Site 4	West Fork White Lick Cr. County Line Road	39.37.49.9	86.23.30.1
Site 5	West Fork White Lick Cr. State Road 42	39.36.35.2	86.22.58.8
Site 6	West Fork White Lick Cr. State Road 67	39.33.55.2	86.22.29.6
Site 7	Monical Branch Merriman Road	39.33.50.4	86.23.39.1
Site 8	Monical Branch Country Club Road	39.33.14.2	86.22.10.3
Site 9	White Lick Creek Centerton Road	39.33.14.2	86.22.10.3
Site 10	White Lick Creek Wetzel Road	39.33.31.2	86.21.19.0
Site 11	Orchard Creek Rooker Road	39.35.7.8	86.21.11.0
Site 12	Orchard Creek State Road 144	39.35.47.3	86.20.45.9

Figure 2. Location of study sites in White Lick Creek Watershed



METHODS

WATER CHEMISTRY

Basic water chemistry parameters (dissolved oxygen, pH, temperature, and conductivity) were measured on-site during each study period at the same time the macroinvertebrates samples were collected. Dissolved oxygen and temperature were measured with a YSI membrane electrode. Conductivity and pH were measured with a hand-held platinum electrode cell and electrometric glass electrode, respectively. Additional water chemistry results collected by Christopher B. Burke Engineering (CBBEL) are attached in the Appendix.

AQUATIC COMMUNITY

Because they are considered to be more sensitive to local conditions and respond relatively rapidly to change, benthic (bottom-dwelling) organisms were considered to be the primary tool to document the biological condition of the streams. The U.S. Environmental Protection Agency (EPA) has recently developed a "rapid bioassessment" protocol [3] which has been shown to produce highly reproducible results that accurately reflect changes in water quality. We used a modification of this protocol developed by Ohio EPA [4]. This protocol relies upon comparison of the aquatic community to a “reference” condition. A reference site is a stream of similar size in the same geographic area which is least impacted by human changes in the watershed.

Habitat Evaluation

The aquatic habitat at each study site was evaluated according to the method described by Ohio EPA [4]. This method’s results assigns values to various habitat parameters (e.g. substrate quality, riparian vegetation, channel morphology, etc.) and results in a numerical score for each site. Higher scores indicate higher aquatic habitat value. The maximum value for habitat using this assessment technique is 100.

Sample Collection (Macroinvertebrates)

Macroinvertebrate samples in this study were collected by dipnet in riffle areas where current speed approached 30 cm/sec. All samples were preserved in the field with 70% isopropanol.

Laboratory Analysis (Macroinvertebrates)

In the laboratory, a 100 organism subsample was prepared from each site by evenly distributing the animals collected in a white, gridded pan. Grids were randomly selected and all organisms within grids were removed until 100 organisms had been selected from the entire sample.

Each animal was identified to the lowest practical taxon (usually genus or species) using standard taxonomic references [5,6]. As each new taxon was identified, a representative specimen was preserved as a "voucher." All voucher specimens will ultimately be deposited in the Purdue University Department of Entomology collection.

Data Analysis (Macroinvertebrates)

Following identification of the animals in the sample, ten "metrics" are calculated for each site. These metrics are based on knowledge about the sensitivity of each species to changes in environmental conditions and how the benthic communities of unimpacted ("reference") streams are usually organized. For example, mayflies and caddisflies are aquatic insects which are known to be more sensitive than most other benthic animals to degradation of environmental conditions. A larger proportion of these animals in a sample receives a higher score. The sum of all ten metrics provides an individual "biotic score" for each site.

The metrics used in this study were adapted from Ohio EPA. Because Ohio EPA uses a larger sample size in its macroinvertebrate protocol, some of the metrics were modified to more closely correspond to a 100 organism sample. In addition, since a separate qualitative sample was not taken, the U.S. EPA metric "% Dominant Taxon" was substituted for the "EPT Qualitative Taxa" metric used in Ohio. The following scoring values were used in this study:

SCORING VALUES FOR METRICS
Adapted from Ohio EPA and U.S. EPA RBA Protocol III.

	6 points	4 points	2 points	0 points
# of Genera	>20	14 - 20	7 - 13	<7
# Mayfly Taxa	> 6	4 - 6	2 - 4	<2
# Caddisfly Taxa	> 4	3 - 4	1 - 2	0
# Diptera Taxa	>12	8 - 12	4 - 7	<4
% Tanytarsini	>25	11 - 25	1 - 10	0
% Mayflies	>25	11 - 25	1 - 10	0
% Caddisflies	>20	11 - 19	1 - 10	0
% Tolerant Species	0-10	11 - 20	21 - 30	>30
% non-Tanytarsids & non-insects	<25	25 - 45	46 - 65	>65
% Dominant Taxon	<20	21-29	30-39	>40

Because the index scores for macroinvertebrates and habitat result in different maximum values, they are difficult to relate to each other. Therefore, both indices were eventually converted to a normalized score of 0 to 100 using the following formula:

Normalized Score = Actual Score / Maximum Possible Score x 100

RESULTS

Water Chemistry

Table 1 shows a summary of all the water chemistry data collected at the 12 sites examined in this study:

	Dissolved Oxygen (mg/l)		pH SU		Temp. Deg. C		Cond. uS	
	Apr.	Oct.	Apr.	Oct.	Apr.	Oct.	Apr.	Oct.
Site 1	9.4	10.4	7.8	7.8	15.4	13.0	700	900
Site 2	9.9	12.3	7.8	7.8	15.9	12.5	590	800
Site 3	9.8	13.2	8.1	8.1	16.5	12.5	630	800
Site 4	11.8	11.5	8.4	7.9	19.5	14.0	550	600
Site 5	11.8	10.8	8.4	8.0	18.4	14.0	560	800
Site 6	10.9	12.5	8.3	8.2	18.0	14.5	570	700
Site 7	10.0	8.4	7.9	7.6	15.7	14.0	370	500
Site 8	9.8	9.1	8.3	7.9	16.5	11.5	360	500
Site 9	10.0	15.8	8.2	8.4	17.7	14.5	560	700
Site 10	11.1	13.0	8.2	8.2	17.7	15.0	570	700
Site 11	9.9	10.0	8.1	7.3	15.8	13.0	430	600
Site 12	11.1	6.7	8.2	7.4	16.4	12.0	420	600

Aquatic Habitat Analysis

Table 2 shows the results of the QHEI aquatic habitat values for each site in the study.

Table 2. Aquatic Habitat

		Score
Site 1	E. Fork White Lick Cr. CR 700 S Hendricks Co.	81
Site 2	E. Fork White Lick Cr. Old State Rd. 67	84
Site 3	E. Fork White Lick Cr. E. Carol Ln.	84
Site 4	W. Fork White Lick Cr. County Line Rd.	84
Site 5	W. Fork White Lick Cr. State Road 42	83
Site 6	W. Fork White Lick Cr. State Rd. 67	87
Site 7	Monical Branch Merriman Rd.	56
Site 8	Monical Branch Country Club Rd.	65
Site 9	White Lick Cr. Centerton Rd.	80
Site 10	White Lick Cr. Wetzel Rd.	84
Site 11	Orchard Cr. Rooker Rd.	69
Site 12	Orchard Cr. State Rd 144	70

The results of the "Index of Biotic Integrity" (IBI) scores and their relative ranks from best biological condition (1) to worst biological condition (12) are shown in Table 3.

Table 3. Summary of IBI "Normalized" Scores for Macroinvertebrates

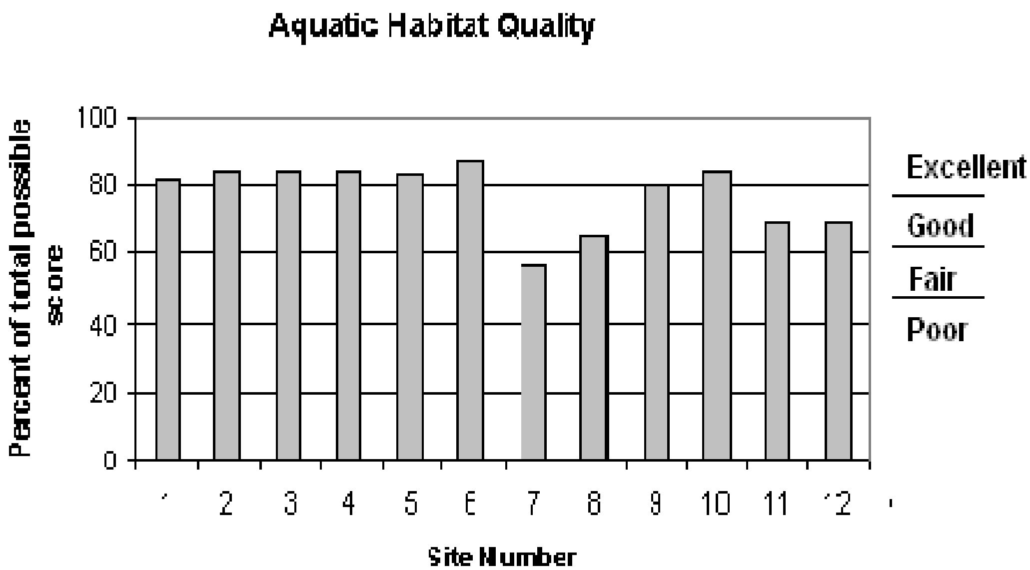
		4/04 Score	10/04 Score	Mean Score	Rank
Site 1	E. Fork White Lick CR 700 S Hendricks Co.	20	63	41	9
Site 2	E. Fork White Lick Cr. Old State Rd. 67	27	57	42	8
Site 3	E. Fork White Lick Cr. E. Carol Ln.	27	57	42	7
Site 4	W. Fork White Lick Cr. County LIne Rd.	27	50	39	11
Site 5	W. Fork White Lick Cr. State Road 42	17	67	42	6
Site 6	W. Fork White Lick Cr. State Rd. 67	37	53	45	5
Site 7	Monical Branch Merriman Rd.	43	57	50	3
Site 8	Monical Branch Country Club Rd.	53	63	58	2
Site 9	White Lick Cr. Centerton Rd.	13	50	32	12
Site 10	White Lick Cr. Wetzel Rd.	33	60	47	4
Site 11	Orchard Cr. Rooker Rd.	47	70	59	1
Site 12	Orchard Cr. State Rd 144	27	53	40	10

DISCUSSION

Aquatic Habitat

Figure 3 shows a graphical comparison of aquatic habitat at each site. Aquatic habitat index values ranged from 56 to 87. Eight sites have "excellent" aquatic habitat, three have "good" habitat, and one was "fair". The site with "fair" habitat (Monical Branch at Merriman Road) had a very narrow zone of riparian vegetation and sparse in-stream cover.

Figure 3.

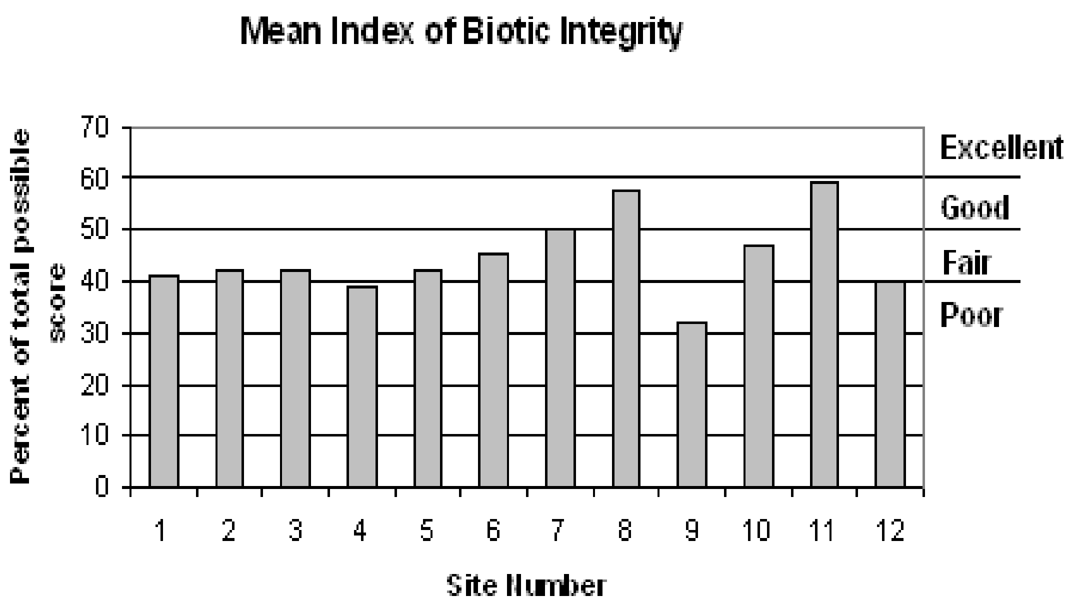


Macroinvertebrate Communities

A total of 46 macroinvertebrate genera were collected at the 12 sites studied. The most commonly collected species were midge larvae (especially *Orthocladius obumbratus*, a sediment-tolerant species [5]) and caddisflies (especially *Cheumatopsyche* spp., a rather pollution-tolerant net spinner).

Scores for the spring and fall collections were averaged. The scores for the spring collections were lower than those from the fall. The mean normalized biotic index scores in the White Lick Creek watershed ranged from 32 to 59 (Figure 4), which means that all sites were at impacted compared to regional "reference" sites. Two sites were in the"good" category", eight were in the "fair" category", and two were in the "poor" category.

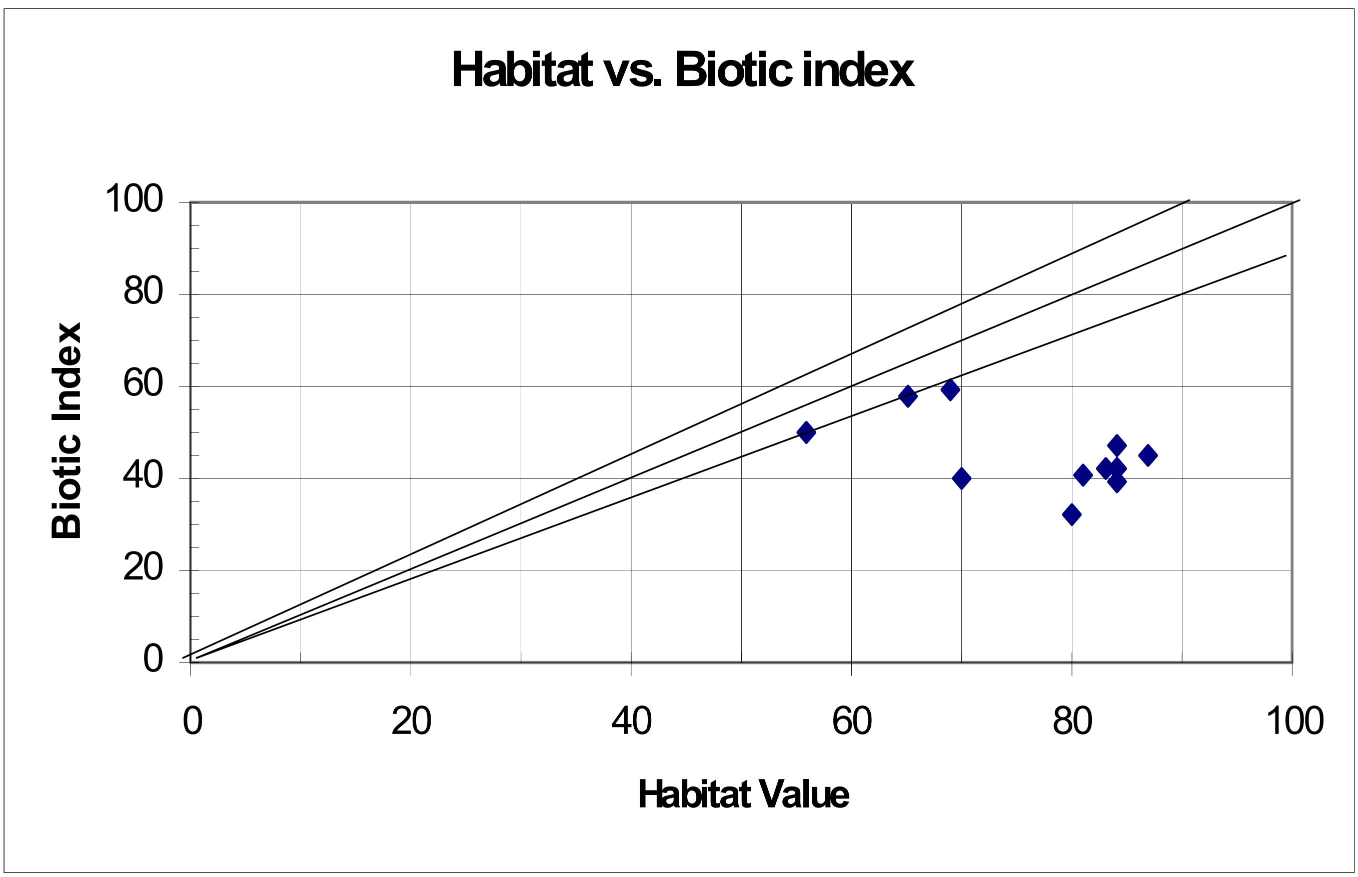
Figure 4



Diagnosis

One of the most useful aspects of biological monitoring is that we can use information on the way aquatic animals respond to different types of stress to diagnose a problem. For example, degraded biotic integrity can often be directly related to degraded habitat. Macroinvertebrates cannot thrive where habitat is lacking. When the two values are graphed in relation to each other, they form a straight line [3]. A measurement error of plus or minus 10% can be added to the graph to give a range in which biotic integrity degradation is explained simply by a lack of adequate habitat. When values fall outside this range, however, water quality problems are suspected. A comparison of biotic integrity to habitat is shown in Fig. 6. This figure suggests that three sites (on Monical Branch and Orchard Creek) had relatively good water quality. The remaining nine sites had degraded water quality in at least one sampling period. All of the White Lick Creek and East Fork of White Lick Creek sites had fairly degraded water quality.

Figure 6



The degree of biological impairment in East Fork, West Fork, and the mainstem of White Lick Creek remains fairly constant as it enters and flows through Morgan County. This indicates at least some of the water quality problems are originating in the upstream regions of the watershed, including several urban areas (Brownsburg, Avon, Danville, and Plainfield). The non-urban portions of the watershed are dominated by row-crop agriculture. Chemical parameters measured during the study (dissolved oxygen, pH, temperature, and conductivity) were within normal range, although pH values greater than 8.3 (measured in White Lick Creek at several sites during both April and October) indicate the presence of intense algal activity, often stimulated by excessive nutrient inputs.

An examination of those metrics showing the lowest values may provide an important clue about causes of biological impairment. A healthy stream will support a diverse community of macroinvertebrates. Diversity is reflected in the metrics "number of macroinvertebrate genera" and "percent dominant taxon". Spring collections were dominated by midge larvae, and fall collections had large numbers of the caddisfly *Cheumatopsyche*. For both the spring and fall collections,, the number of mayfly taxa was low in White Lick Creek. This sometimes indicates a low-level toxicity response.

All sites (except Monical Branch and Orchard Creek) were dominated during the spring collections by a midge species (*Orthocladius obumbratus*) known to be tolerant to high amounts of sediment deposition. Moderate to severe bank erosion was noted at most sites. Excessive sediment inputs may be playing an important role in keeping the benthic community from being as diverse as it could be at these sites.

RECOMMENDATIONS

(1) Protect habitat by discouraging channelization and clear-cutting of riparian vegetation. Enhance habitat in Monical Branch by restoring riparian vegetation in the upper part of the watershed.

(2) Reduce sedimentation by controlling bank erosion, and encouraging good land-use practices that do not add excessive silt to the stream.

(3) Coordinate with agencies upstream to improve water quality upstream from Morgan County.

LITERATURE CITED

1. Karr, J.R. et al., 1986. Assessing biological integrity in running waters: a method and its rationale. Illinois Natural History Survey Special Publication 5, 28 pp.

2. Omernik, J.M. and A.L. Gallant. 1988. Ecoregions of the Upper Midwest States. U.S. EPA Environmental Research Laboratory, Corvallis, OR. EPA/600/3-88/037.

3. Plafkin. J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers. U.S. EPA Office of Water, Washington, D.C. EPA/444/4-89-001.

4. Ohio EPA. 1987. Biological criteria for the protection of aquatic life: Vol. II. Users manual for biological field assessment of Ohio surface waters. Div. of Water Quality Monitoring and Assessment, Columbus, OH.

5. Simpson, K.W. and R.W. Bode. 1980. Common Larvae of Chironomidae (Diptera) from New York State Streams and Rivers. Bull. No. 439. NY State Museum, Albany, NY. 105 pp.

6. Merrit, R.W. and K.W. Cummins. 1996. An Introduction to the Aquatic Insects of North America. Third Edition. Kendall/Hunt Publishing Company, Dubuque, Iowa. 862 pp.

Rapid Bioassessment Results - Macroinvertebrates
April 2004

	Site # 1	2	3	4	5	6
Chironomidae (Midges)						
Parametriocnemus lundbecki	18		8			6
Heterotrissocladius spp.						
Orthocladius obumbratus	55	64	79	44	65	55
Cricotopus bicinctus	3		4	19	25	8
C. tremulus						
C. trifascia		3				
Cardiocladius spp.						
Brillia spp.						
Polypedilum convictum			4	3		
Cryptochironomus fulvus		3		3		
Ablabesmyia mallochi		6				
Simuliidae (Blackflies)						
Simulium spp.	22	16	2	22	3	9
Tabanidae(Horse & Deerflies)						1
Tipulidae (Craneflies)						
Tipula spp.						
Antocha spp.						
Ephemeroptera (Mayflies)						
Stenonema terminatum					2	
S. pulchellum				1		
S. vicarium						
S. femoratum			1		1	
Baetis flavistriga						
B. intercalaris		1				
B. amplus						
Trichoptera (Caddisflies)						
Cheumatopsyche sp.		4	1	1	2	13
Hydropsyche betteni	1		1			
H. orris						
Ceratopsyche bifida				2		5
C. sparna						
Polycentropus						
Chimarra obscura						1
Plecoptera (Stoneflies)						
Perlodidae						
Coleoptera (Beetles)						
Stenelmis larvae		2				2
Macronychus glabratus				1		

Rapid Bioassessment Results - Macroinvertebrates
April 2004 (con't.)

	Site # 1	2	3	4	5	6
Amphipoda (Scuds)		1				
Isopoda (Aquatic Sow Bugs)						
Oligochaeta (Worms)	1					
Total	100	100	100	100	100	100

Rapid Bioassessment Results - Macroinvertebrates
April 2004 (con't.)

	Site #					
	7	8	9	10	11	12
Chironomidae (Midges)						
Parametriocnemus lundbecki	2					
Heterotrissocladius spp.		2				
Orthocladius obumbratus	22	10	23	52	5	5
Cricotopus bicinctus	9	13	13	12		
C. tremulus		10	6			
C. trifascia			4			
Cardiocladius spp.		5				
Brillia spp.					2	
Polypedilum convictum	4	8	2	3	20	61
Cryptochironomus fulvus						
Ablabesmyia mallochi	14	18			3	3
Simuliidae (Blackflies)						
Simulium spp.						
Tabanidae(Horse & Deerflies)						
Tipulidae (Craneflies)						
Tipula spp.	1	3			1	
Antocha spp.	1					
Ephemeroptera (Mayflies)						
Stenonema terminatum						
Stenonema pulchellum				1		
Stenonema vicarium		6			1	
Baetis flavistriga			2		2	
B. intercalaris		3				
B. amplus	2	2		2	41	
Trichoptera (Caddisflies)						
Cheumatopsyche sp.	13	8		9	6	5
Hydropsyche betteni	9	1			4	3
H. orris				1		
Ceratopsyche bifida				3		
C. sparna		3				
Polycentropus		3				
Chimarra obscura						
Plecoptera (Stoneflies)						
Perlodidae		1			1	

Rapid Bioassessment Results - Macroinvertebrates
April 2004 (con't.)

	Site #					
	7	8	9	10	11	12
Coleoptera (Beetles)						
Stenelmis larvae					3	1
Macronychus glabratus						
Amphipoda (Scuds)						1
Isopoda (Aquatic Sow Bugs)	6	1			1	
Oligochaeta (Worms)		1				
Total	100	100	100	100	100	100

Rapid Bioassessment Results - Macroinvertebrates
October 2004

	Site # 1	2	3	4	5	6
Chironomidae (Midges)						
Hydrobaenus spp.						
Stilocladius spp.			3	1		
Georthocladius spp.						
Orthocladius obumbratus	1	1	2	1	1	
O. annectens	1					1
Eukiefferiella bavarica						
Nanocladius spp.	2		1			
Thienemanniella xena						
Cricotopus bicinctus	1	3	6	5	2	
C. tremulus					1	
C. trifascia		2		4	1	2
Cardiocladius spp.		1		2		2
Brillia spp.						
Polypedilum convictum				6	2	1
Glyptotendipes lobiferus					4	
Paratendipes spp.						
Microtendipes caelum					2	
Rheotanytarsus exiguus			2		2	
Tanytarsus spp.			1			
Ablabesmyia mallochi					5	
Simuliidae (Blackflies)						
Simulium spp.	1	6	1	1	1	3
Tipulidae (Craneflies)						
Tipula spp.						1
Antocha spp.						
Hexatoma spp.						
Ephemeroptera (Mayflies)						
Stenonema femoratum					1	
S. pulchellum	3				2	
S. vicarium						
Baetis flavistriga	2	9	7			
B. intercalaris	18	4	40		1	1
B. amplus						
B. hageni						
Tricorythodes spp.			2		2	
Isonychia spp.	5					
Trichoptera (Caddisflies)						
Potamyia flava				1	3	3
Cheumatopsyche sp.	33	30	18	38	45	30
Hydropsyche betteni		5				2

Rapid Bioassessment Results - Macroinvertebrates
October 2004 (cont.)

	Site # 1	2	3	4	5	6
H. orris					4	26
H. simulans						
Ceratopsyche bifida	33	34	17	32	19	14
C. sparna	1	5		5		9
Chimarra obscura				4	2	5
Limnephilidae						
Plecoptera (Stoneflies)						
Perlodidae						
Coleoptera (Beetles)						
Stenelmis larvae						
Odonata (Dragon & Damselflies)						
Hetaerina						
Argia						
Amphipoda (Scuds)						
Isopoda (Aquatic Sow Bugs)						
Oligochaeta (Worms)						
Total	100	100	100	100	100	100

Rapid Bioassessment Results - Macroinvertebrates
October 2004 (con't)

	Site #					
	7	8	9	10	11	12
Chironomidae (Midges)						
Hydrobaenus spp.						
Stilocladius spp.						
Georthocladius spp.					1	
Orthocladius obumbratus	4		3	9		
O. annectens						
Eukiefferiella bavarica					4	3
Nanocladius spp.	5	1			11	4
Thienemanniella xena			1			
Cricotopus bicinctus	2					
C. tremulus	2					
C. trifascia			17	4		
Cardiocladius spp.			1	12		
Brillia spp.						
Polypedilum convictum		3	2	4	9	10
Glyptotendipes lobiferus						
Paratendipes spp.						1
Microtendipes caelum						
Rheotanytarsus exiguus						
Tanytarsus spp.						
Ablabesmyia mallochi		1	1	3	1	4
Simuliidae (Blackflies)						
Simulium spp.	2	7	3	2	1	
Tipulidae (Craneflies)						
Tipula spp.					12	35
Antocha spp.		5				
Hexatoma spp.		3			10	4
Ephemeroptera (Mayflies)						
Stenonema femoratum				1		2
S. pulchellum						
S. vicarium	7	8				14
Baetis flavistriga	4	4		1	9	
B. intercalaris		4	2	15	6	
B. amplus			1			
B. hageni	3					
Tricorythodes spp.				2		
Isonychia spp.				1		

Rapid Bioassessment Results - Macroinvertebrates
October 2004 (con't)

	Site #						
	7	8	9	10	11	12	
Trichoptera (Caddisflies)							
Cheumatopsyche sp.	37	36	40	33	10	14	
Hydropsyche betteni	10	10			3	5	
H. orris			4				
H. simulans			2				
Ceratopsyche bifida	1	8	19	11	1		
C. sparna	5	4	3	1	3		
Chimarra obscura				1	13	1	
Limnephilidae							
Plecoptera (Stoneflies)					2		
Coleoptera (Beetles)							
Stenelmis larvae	1	2	1		1	1	
Odonata (Dragon & Damselflies)							
Hetaerina						1	
Argia	1						
Amphipoda (Scuds)						1	
Isopoda (Aquatic Sow Bugs)	14	2			3		
Turbellaria (Planarians)	1						
Total	100	100	100	100	100	100	100

Data Analysis for Macroinvertebrates - 4/04
METRICS

	Site #					
	1	2	3	4	5	6
# of Genera	6	9	8	10	6	8
Mayfly Taxa	0	1	1	2	3	0
Caddisfly Taxa	1	1	2	2	1	3
Diptera Taxa	4	5	5	5	3	5
% Tanytarsini	0	0	0	0	0	0
% Mayflies	0	1	1	5	5	1
% Caddisflies	1	4	2	3	2	18
% Tolerant Species	4	0	4	19	25	8
% non-Tanytarsid midges & non-insects	99	97	98	92	94	79
% Dominant Taxon	55	64	79	44	65	55

	Site #					
	7	8	9	10	11	12
# of Genera	12	18	5	9	14	9
Mayfly Taxa	1	3	1	2	3	0
Caddisfly Taxa	2	4	0	3	2	3
Diptera Taxa	8	9	6	4	7	4
% Tanytarsini	0	0	0	0	0	0
% Mayflies	1	11	2	3	44	0
% Caddisflies	22	15	0	13	10	9
% Tolerant Species	9	14	13	12	0	0
% non-Tanytarsid midges & non-insects	76	73	98	84	42	90
% Dominant Taxon	22	18	50	52	41	61

SCORING 4/04

	Site #					
	1	2	3	4	5	6
# of Genera	0	2	2	2	0	2
# Mayfly Taxa	0	0	0	2	2	0
# Caddisfly Taxa	2	2	2	2	2	4
# Diptera Taxa	2	2	2	2	0	2
% Tanytarsini	0	0	0	0	0	0
% Mayflies	0	2	2	2	2	2
% Caddisflies	2	2	2	2	2	4
% Tolerant Species	6	6	6	4	2	6
% non-Tanytarsid midges & non-insects	0	0	0	0	0	0
% Dominant Taxon	0	0	0	2	0	2
SCORE	12	16	16	10	10	22
STANDARDIZED SCORE	20	27	27	27	17	37

	Site #					
	7	8	9	10	11	12
# of Genera	2	4	0	2	4	2
# Mayfly Taxa	0	2	0	2	2	0
# Caddisfly Taxa	2	4	0	4	2	4
# Diptera Taxa	4	4	2	2	2	2
% Tanytarsini	0	0	0	0	0	0
% Mayflies	2	4	2	2	6	0
% Caddisflies	6	4	0	4	2	2
% Tolerant Species	6	4	4	4	6	6
% non-Tanytarsid midges & non-insects	0	0	0	0	4	0
% Dominant Taxon	4	6	0	0	0	0
SCORE	26	32	8	20	28	16
STANDARDIZED SCORE	43	53	13	33	47	27

Data Analysis for Macroinvertebrates - 10/04

METRICS

	Site # 1	2	3	4	5	6
# of Genera	9	8	11	10	17	12
Mayfly Taxa	4	2	3	0	4	1
Caddisfly Taxa	3	4	2	5	5	7
Diptera Taxa	5	5	7	7	10	6
% Tanytarsini	0	0	1	0	2	0
% Mayflies	28	13	49	0	6	1
% Caddisflies	67	74	35	80	73	89
% Tolerant Species	1	3	6	5	6	0
% non-Tanytarsid midges & non-insects	5	13	15	20	19	10
% Dominant Taxon	33	34	40	38	45	30

	Site # 7	8	9	10	11	12
# of Genera	14	14	12	13	16	14
Mayfly Taxa	3	3	2	5	2	2
Caddisfly Taxa	4	5	5	4	5	3
Diptera Taxa	6	6	7	6	8	7
% Tanytarsini	0	0	0	0	0	0
% Mayflies	14	16	3	20	15	16
% Caddisflies	53	60	68	46	30	20
% Tolerant Species	2	0	0	0	0	0
% non-Tanytarsid midges & non-insects	31	22	28	34	52	61
% Dominant Taxon	37	36	40	33	13	35

SCORING

	Site # 1	2	3	4	5	6
# of Genera	2	2	2	2	4	2
# Mayfly Taxa	4	2	2	0	4	0
# Caddisfly Taxa	4	4	2	6	6	6
# Diptera Taxa	2	2	2	2	4	2
% Tanytarsini	0	0	2	0	2	0
% Mayflies	6	4	6	0	2	2
% Caddisflies	6	6	6	6	6	6
% Tolerant Species	6	6	6	6	6	6
% non-Tanytarsid midges & non-insects	6	6	6	6	6	6
% Dominant Taxon	2	2	0	2	0	2
SCORE	38	34	34	30	40	32
STANDARDIZED SCORE	63	57	57	50	67	53

	Site # 7	8	9	10	11	12
# of Genera	4	4	2	2	4	4
# Mayfly Taxa	2	2	2	4	2	2
# Caddisfly Taxa	4	6	6	6	6	4
# Diptera Taxa	2	2	2	2	4	2
% Tanytarsini	0	0	0	0	0	0
% Mayflies	4	4	2	4	4	4
% Caddisflies	6	6	6	6	6	6
% Tolerant Species	6	6	6	6	6	6
% non-Tanytarsid midges & non-insects	4	6	4	4	4	2
% Dominant Taxon	2	2	0	2	6	2
SCORE	34	38	30	36	42	32
STANDARDIZED SCORE	57	63	50	60	70	53

Aquatic Habitat Scoring

Site Number

	1	2	3	4	5	6
SUBSTRATE	12	12	12	12	10	12
COVER	9	10	10	10	10	10
CHANNEL	14	14	14	14	13	14
RIPARIAN	14	14	14	11	13	13
POOL/RIFFLE	12	14	14	14	14	15
GRADIENT	10	10	10	10	10	10
DRAINAGE AREA	10	10	10	13	13	13
TOTAL	81	84	84	84	83	87

Site Number

	7	8	9	10	11	12
SUBSTRATE	10	10	12	12	12	12
COVER	6	7	8	8	8	8
CHANNEL	11	12	14	14	14	12
RIPARIAN	7	9	11	12	12	17
POOL/RIFFLE	9	12	12	15	11	10
GRADIENT	8	8	10	10	6	6
DRAINAGE AREA	5	7	13	13	6	5
TOTAL	56	65	80	84	69	70

CBBEL Water Chemistry Data

Sample Date	Watershed	Site	PH su	Temp C	E.coli cfu/100	D.O. mg/l	Cond uS	TSS mg/l	Turb NTU	Tot P mg/l	TOC mg/l
12/3/2003	East Fork	1WLC	8.6	4.9	120	8.6	726	9	6.8	0.1	2.7
12/3/2003	East Fork	2WLC	8.4	4.8	160	8.5	711	7	5.6	0.07	2.5
12/3/2003	East Fork	3WLC	8.3	4.8	190	11.4	728	7	6.2	0.08	2.5
12/3/2003	West Fork	4WLC	8.4	5	650	11.3	719	5	4.7	0.14	2.3
12/3/2003	West Fork	5WLC	8.4	4.1	390	12	647	<4	2	<.03	2.8
12/3/2003	West Fork	6WLC	8.4	5	390	11.3	719	6	4.8	0.13	2.3
12/3/2003	Monical	7WLC	8.8	5.7	410	10.4	376	17	11	0.04	2.6
12/3/2003	Monical	8WLC	8.4	4.9	250	11.7	562	<4	4.4	<.03	2.1
12/3/2003	Monical	9WLC	8.4	5.6	390	10.2	697	7	5	0.12	2.3
12/3/2003	Orchard	10WLC	8.4	5.1	1200	11.2	343	4	4.5	0.12	2.4
12/3/2003	Orchard	11WLC	8.3	4.7	260	11.5	622	<4	2.3	0.04	3.1
12/3/2003	Orchard	12WLC	8.3	4	2400	8.9	624	<4	3.8	0.04	3.2
1/12/2004	East Fork	1WLC	8.2	3.8	870	11.7	437	10	7.9	0.11	2.7
1/12/2004	East Fork	2WLC	8.1	3.8	550	11.6	671	10	8	0.07	2.3
1/12/2004	East Fork	3WLC	8.2	4.1	240	11.4	727	11	8	0.08	2.4
1/12/2004	West Fork	4WLC	8.2	3.6	550	12.1	689	13	10	0.13	2.2
1/12/2004	West Fork	5WLC	8.3	3.3	96	12.6	581	9	6	<0.03	2.3
1/12/2004	West Fork	6WLC	8.2	3.6	490	10.8	698	19	12	0.11	2.2
1/12/2004	Monical	7WLC	8	4.2	330	11	514	14	14	0.03	2.5
1/12/2004	Monical	8WLC	8.2	3.7	280	11.8	504	10	10	<0.03	2.1
1/12/2004	Monical	9WLC	8.1	3.9	610	11.6	686	24	14	0.1	2.1
1/12/2004	Orchard	10WLC	8.1	3.9	2400	11.2	691	19	12	0.11	2.1
1/12/2004	Orchard	11WLC	8.2	3.9	370	9.3	524	6	8	0.04	2.5
1/12/2004	Orchard	12WLC	8.3	3.1	650	11.6	562	6	6.2	0.06	2.5
2/17/2004	East Fork	1WLC	8.6	0.7	520	13.4	475.1	8	8.4	0.29	le
2/17/2004	East Fork	2WLC	8.3	0.7	47	13.6	449	7	9	0.16	le
2/17/2004	East Fork	3WLC	8.3	1.7	47	12.6	470	11	11	0.16	le
2/17/2004	West Fork	4WLC	8.3	1.1	86	13.4	443	7	6	0.22	le
2/17/2004	West Fork	5WLC	8.4	0.1	100	13.5	341	<4	2	<.03	le
2/17/2004	West Fork	6WLC	8.3	1.2	46	11.8	444	5	5	0.23	le
2/17/2004	Monical	7WLC	8.2	2.5	870	12.4	350	<4	3.7	<.03	le
2/17/2004	Monical	8WLC	8.4	0.8	210	13	309	<4	3.4	<.03	le
2/17/2004	Monical	9WLC	8.3	1.7	70	12.6	437	9	4.5	0.17	le
2/17/2004	Orchard	10WLC	8.3	1.8	61	12.7	449	<4	1.9	0.03	le
2/17/2004	Orchard	11WLC	8.4	1.7	31	13.2	331	5	6.8	0.19	le
2/17/2004	Orchard	12WLC	8.4	0.6	120	14.8	307	<4	2.8	0.03	le
3/3/2004	East Fork	1WLC	8.2	6.8	340	9.6	485	13	9.2	0.09	2.7
3/3/2004	East Fork	2WLC	8.2	6.8	91	9.7	470	14	9	0.09	2.7

3/3/2004	East Fork	3WLC	8.3	7.5	290	10.3	287	13	8	0.11	3.2
3/3/2004	West Fork	4WLC	8.4	6.8	580	10.1	411	32	20	0.14	2.8
3/3/2004	West Fork	5WLC	8.5	5.6	330	10.9	350	7	3.2	<.03	1.7
3/3/2004	West Fork	6WLC	8.4	6.9	260	8.5	407	32	23	0.15	2.7
3/3/2004	Monical	7WLC	8.2	6.7	310	9.6	347	9	5.6	<.03	1.7
3/3/2004	Monical	8WLC	8.5	6	45	10.2	317	9	5.2	<.03	1.6
3/3/2004	Monical	9WLC	8.3	7.3	240	9.4	391	39	25	0.15	6.7
3/3/2004	Orchard	10WLC	8.3	7.2	310	9.8	427	27	20	0.15	4.8
3/3/2004	Orchard	11WLC	8.7	6.8	130	12.5	317	7	3.9	0.04	2.6
3/3/2004	Orchard	12WLC	8.6	7.3	230	10.5	361	9	4.3	0.05	2.7
4/7/2004	East Fork	1WLC	8.2	10.6	55	6.2	542	7	6	0.14	2.8
4/7/2004	East Fork	2WLC	8.1	11.1	86	7.8	531	10	8	0.08	2.7
4/7/2004	East Fork	3WLC	8.2	12.1	50	9.3	439	7	1.9	0.03	2.6
4/7/2004	West Fork	4WLC	8.2	11.3	84	8.3	505	12	7	0.12	2.3
4/7/2004	West Fork	5WLC	8.4	11.1	2400	8.8	452	8	5.3	<.03	3.1
4/7/2004	West Fork	6WLC	8.2	11.5	170	7.1	522	10	6.6	0.12	2.6
4/7/2004	Monical	7WLC	8.2	12	34	7.9	410	5	4.2	<.03	2.4
4/7/2004	Monical	8WLC	8.4	11.4	50	8.8	379	4	3.3	<.03	2.1
4/7/2004	Monical	9WLC	8.2	12.2	870	8.1	392	10	4.8	0.1	2.4
4/7/2004	Orchard	10WLC	8.2	12	870	8	531	10	5	0.12	2.4
4/7/2004	Orchard	11WLC	8.4	13.1	50	9.5	443	<4	1.7	0.03	2.7
4/7/2004	Orchard	12WLC	8.2	12.7	58	9.4	443	<4	1.9	0.03	2.5
5/6/2004	East Fork	1WLC	8	16.2	520	4.4	668	10	5.9	0.25	3.4
5/6/2004	East Fork	2WLC	8.1	16.4	200	5.9	595	6	5.1	0.17	2.9
5/6/2004	East Fork	3WLC	8.2	19.6	170	7.2	482	7	3.4	0.12	3
5/6/2004	West Fork	4WLC	8.2	17.8	82	6.3	665	11	6.4	0.19	2.7
5/6/2004	West Fork	5WLC	8.3	19.5	330	6.5	551	<4	1.2	<.03	2.1
5/6/2004	West Fork	6WLC	8.2	18.6	30	5.7	672	8	5.3	0.17	2.6
5/6/2004	Monical	7WLC	8	16.9	310	6	463	6	5.2	<.03	2.4
5/6/2004	Monical	8WLC	8.2	17.5	150	6.2	451	5	4.7	<.03	2.1
5/6/2004	Monical	9WLC	8.3	20.5	29	6.8	689	6	3	0.17	2.9
5/6/2004	Orchard	10WLC	8.2	20.2	23	7.9	696	8	4	0.19	2.7
5/6/2004	Orchard	11WLC	8.3	19.3	55	6.4	534	15	8.3	0.08	3
5/6/2004	Orchard	12WLC	8.2	18.9	200	5.4	588	<4	1.3	0.05	3.4
6/9/2004	East Fork	1WLC	8	23.2	490	3.4	667	12	8.6	0.22	2.6
6/9/2004	East Fork	2WLC	8	22.2	460	3.8	654	11	6.4	0.14	2.2
6/9/2004	East Fork	3WLC	8.1	21.6	230	4.8	589	10	5.1	0.11	2.5
6/9/2004	West Fork	4WLC	8.2	23.6	210	5.6	705	13	6.7	0.16	2.4
6/9/2004	West Fork	5WLC	8.2	21.7	2400	5.9	593	31	21	0.09	9
6/9/2004	West Fork	6WLC	8.3	23.8	210	5.8	709	11	5.3	0.14	2.4
6/9/2004	Monical	7WLC	7.9	21	920	5.1	560	10	6.9	<0.03	2.4
6/9/2004	Monical	8WLC	8.2	21.5	770	5.9	514	16	9.4	<0.03	2

6/9/2004	Monical	9WLC	8.4	24.7	110	6.2	722	12	5	0.13	2.3
6/9/2004	Orchard	10WLC	8.2	24.8	96	7	732	8	4	0.16	2.2
6/9/2004	Orchard	1WLC	8	22.2	390	5.1	587	5	2.2	0.06	1.9
6/9/2004	Orchard	12WLC	8.2	23.6	980	5.4	689	9	5.1	0.1	2.6
7/27/2004	East Fork	1WLC	8.5	19.4	690	2.5	560	16	14	0.19	3.2
7/27/2004	East Fork	2WLC	8.4	19	820	3.4	569	11	9.5	0.17	3.1
7/27/2004	East Fork	3WLC	8.5	18.4	490	4.1	550	15	9.8	0.14	3
7/27/2004	West Fork	4WLC	8.5	20.9	330	3.5	623	15	10	0.18	3
7/27/2004	West Fork	5WLC	8.7	20.5	440	3.4	572	9	1.9	<0.03	2
7/27/2004	West Fork	6WLC	8.5	20.2	290	3.2	603	12	8	0.18	2.8
7/27/2004	Monical	7WLC	8.3	16.6	580	4.3	485	4	3.4	<0.03	1.7
7/27/2004	Monical	8WLC	8.6	17	250	5.3	590	6	3.2	<0.03	1.5
7/27/2004	Monical	9WLC	8.3	18.8	260	5.6	566	16	9.9	0.15	3.1
7/27/2004	Orchard	10WLC	8.4	19.4	220	3.3	655	12	8.2	0.17	3
7/27/2004	Orchard	11WLC	8.4	17.1	260	3.4	640	<4	1.2	0.04	2.3
7/27/2004	Orchard	12WLC	8.5	17	730	3.5	565	<4	2.2	0.05	2.9
8/23/2004	East Fork	1WLC	8.5	19	520	4.3	545	12	12	0.18	3.4
8/23/2004	East Fork	2WLC	8.6	18.9	280	4.1	505	13	11	0.19	3.4
8/23/2004	East Fork	3WLC	8.5	19.2	650	4.5	491	13	11	0.19	3.4
8/23/2004	West Fork	4WLC	8.5	20.1	520	4.1	564	14	13	0.19	3.5
8/23/2004	West Fork	5WLC	8.4	19.6	550	3.9	523	15	12	0.2	3.3
8/23/2004	West Fork	6WLC	8.3	18.1	460	4.6	498	<4	1.6	<0.03	1
8/23/2004	Monical	7WLC	8.4	17.2	330	4.4	512	<4	1.6	<0.03	1
8/23/2004	Monical	8WLC	8.4	18.2	1400	4.02	522	43	39	<0.03	1.7
8/23/2004	Monical	9WLC	8.5	19.1	1600	4.4	496	38	38	<0.03	1.7
8/23/2004	Orchard	10WLC	8.5	19.6	690	4	502	26	3.6	<0.03	2.6
8/23/2004	Orchard	11WLC	8.4	19.4	820	4.3	436	6	2.8	<0.03	2.6
8/23/2004	Orchard	12WLC	8.6	20.1	1200	3.8	601	22	4	<0.03	2.7
9/30/2004	East Fork	1WLC	8.6	15.3	240	8.1	593	6	6.8	0.74	3.1
9/30/2004	East Fork	2WLC	8.5	14.8	280	8.3	732	<4	2.6	0.38	2.6
9/30/2004	East Fork	3WLC	8.5	16	78	8.9	739	<4	2.2	0.26	2.7
9/30/2004	West Fork	4WLC	8.4	17.8	57	7	692	8	5.6	0.14	2.6
9/30/2004	West Fork	5WLC	dry	dry	dry	dry	dry	dry	dry	dry	dry
9/30/2004	West Fork	6WLC	8.4	17.3	78	7.3	656	6	4.3	0.13	2.6
9/30/2004	Monical	7WLC	dry	dry	dry	dry	dry	dry	dry	dry	dry
9/30/2004	Monical	8WLC	8.6	13.4	250	6.4	437	6	2.8	<0.03	1.7
9/30/2004	Monical	9WLC	8.5	17.7	46	8.2	576	4	3.3	0.21	2.5
9/30/2004	Orchard	11WLC	8.5	15.1	170	4.9	481	<4	1.2	<0.03	1.4
9/30/2004	Orchard	12WLC	8.6	14.4	280	5.5	502	<4	1.2	<0.03	1.3
10/29/2004	East Fork	1WLC	8.5	12.2	980	7.6	312	21	18	0.21	4.2
10/29/2004	East Fork	2WLC	8.5	12.2	770	8.4	281.5	21	16	0.19	4.4
10/29/2004	East Fork	3WLC	8.5	12.1	730	8.4	428	17	13	0.18	4.4

10/29/2004	West Fork	4WLC	8.6	12.2	1200	8.3	349	26	18	0.21	4.8
10/29/2004	West Fork	5WLC	8.6	12	>2400	8.3	443	9	4.8	<.03	3.4
10/29/2004	West Fork	6WLC	8.6	12.2	1700	8.4	449	26	18	0.22	4.7
10/29/2004	Monical	7WLC	8.4	12.1	270	7.5	409	4	3.6	0.04	3.6
10/29/2004	Monical	8WLC	8.6	11.8	650	6.4	428	6	7	0.04	3.4
10/29/2004	Monical	9WLC	8.6	12.2	1100	8.1	433	47	29	0.23	4.8
10/29/2004	Orchard	10WLC	8.6	12.2	>2400	8.5	443	37	22	0.23	5
10/29/2004	Orchard	11WLC	8.5	12.1	613	6.5	415	<4	2.4	0.08	4.8
10/29/2004	Orchard	12WLC	8.5	12.1	1700	6.5	415	<4	1.6	0.1	5.9
11/29/2004	East Fork	1WLC	8.3	7.1		10.3	316				
11/29/2004	East Fork	2WLC	8.5	7.1		10.5	357				
11/29/2004	East Fork	3WLC	8.4	7.2		9.4	321				
11/29/2004	West Fork	4WLC	8.4	7.1		9.5	373				
11/29/2004	West Fork	5WLC	8.4	7.9		10.5	380				
11/29/2004	West Fork	6WLC	8.4	7.1		9.5	382				
11/29/2004	Monical	7WLC	8.4	7.4		9.7	303				
11/29/2004	Monical	8WLC	8.5	7.4		10.4	381				
11/29/2004	Monical	9WLC	8.4	7.1		10.1	333				
11/29/2004	Orchard	10WLC	8.4	7.2		10.3	361				
11/29/2004	Orchard	11WLC	8.4	7.1		10.6	377				
11/29/2004	Orchard	12WLC	8.4	7		11.2	398				

Photographs of Study Sites

Site 1 - EF White Lick Cr.
Camby area

Site 2 - EF White Lick Cr.
Hwy 67

Site 3 - EF White Lick Cr.
Near mouth

Site 4 - White Lick Cr.
County Line

Site 5 - White Lick Cr.
Hwy 42

Site 6 - White Lick Cr.
Hwy 67

Site 7 - Monical Branch
Upstream

Site 8 - Monical Branch
Downstream

Site 9 - White Lick Cr.
Centerton Rd.

Site 10 - White Lick Cr.
Wetzel Rd.

Site 11 - Orchard Cr.
Downstream

Site 12 - Orchard Cr.
Upstream